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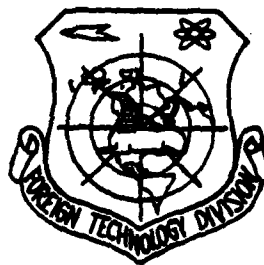
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AERONAUTICAL KNOWLEDGE
(Selected Articles)



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PREPARED BY:

TRANSLATION DIVISION
 FOREIGN TECHNOLOGY DIVISION
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Airship Materials

By
Qian Hongyuan

As of today, airships in foreign countries can be classified into three types: the rigid, semi-rigid and non-rigid. Their basic structure includes ship body, power-propelling units, cabin and other equipment. The ship body which constitutes an absolutely large part of an airship is filled with floating-lifting gas to produce buoyant force. The materials used for building the ship body of an airship are of no more than two different kinds: one is rigid material, such as the skeleton of the body of a rigid airship and the suspension cables in a non-rigid airship, and the other is non-rigid material, such as the body material of a non-rigid airship, air chamber, the cover of a rigid airship and air bag. In the past, airships usually use wood, duralumin, specially made steel pipes and steel cables as structure materials, and cotton glued cloth or cow intestine skin as cover and air bag materials. By now there have been various kinds of plastic materials, synthetic fabrics, light metal alloy and compound materials and they can all be used in building airships. The modern compound materials, such as boron fibre compound material and carbon fibre compound material, and the light metal alloy, such as Ti-Be alloy and Al-Mg alloy, can all be used as structure materials, and they can, at the same time, improve the specific strength and reduce the weight of airship. The advent of plastic films and organic fibre with high strength provides new materials for cover and air bag.

In the following, we try mainly to introduce materials for airship body and air bag. As for structure materials, materials used in manufacturing aircrafts have already been introduced by many and we do not want to make any repetition.

The Development of Air Bag Materials

In the past, the air bag and the outer cover of an airship are usually made of cotton glued cloth. Airships of earlier days are built by using material that is made of cow intestine skin sandwiched between tow layers of cotton cloth. The cow intestine skin has the function to prevent the leaking of floating-lifting gas. When the rigid airship "Los Angeles" is built, for instance, intestine skins of four hundred-thousand heads of cows are use to make its air bag (see Figure 1). The properties of this material in weight,

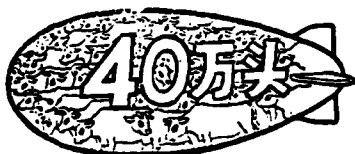


Figure 1 Air bag made of cow intestine skin

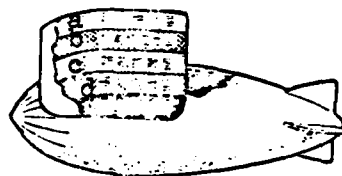


Figure 2 The layers of air bag material

a. protection layer; b. shearing stress resistance layer; c. Helium diffusing prevention layer; d. stress bearing layer.

strength and air permeability are poor and the source of this material is limited as well. Later a material of cotton fabric painted with a paint that is made of nitro-cotton or cellulose acetate solved in a solvent is developed. Of the rigid airship "Macon" built in the Unites States in 1933, for example, the air bag material is cotton cloth coated with such kind

of paint. Its cover material is also cotton cloth coated several layers of this kind of paint, and on the outer surface of the cover, a paint made of aluminum powder is added as protection layer. As a result of the development of synthetic materials, many kinds of new materials have become available in recent years, such as polyester fabrics or nylon fabrics coated with multi-chloroprene gum. Many non-rigid airships built after the thirties use this kind of materials.

So far as the body as well as the air bag materials of an airship filled with helium are concerned, they must have high strength/weight ratio and low helium permeability, good outdoor weatherability, crack resistance and crack extension resistance. They are also required to be able to maintain their property without lowering it after many times of breaking and they must be easy to be connected and repaired without high cost. It is hardly possible to satisfy the above requirements by using only one kind of material. So cloth coated with gum (namely gummed cloth) or ply-materials are often used.

At present, the body of a non-rigid airship inflated with helium is composed of the following parts: protection layer, helium diffusion prevention layer and stress bearing layer.

Protection Layer: Airships are constantly used outdoor for a long period of time, and they always confront wind, rain, sunshine and cold. In order to prolong the life time of an airship, there must be a protection layer on the outer surface of its body. Thereby it can stand the tests of various kinds of weather and environments. Generally the protection layer is made

of polyester, and a layer of polyvinyl chloro-sulfonated is painted on the polyester periodically. The polyvinyl chloro-sulfonated is a special kind of glue which has excellent outdoor weatherability. In recent years, the protection layer has changed to use polyflouro-ethene, which shows a very good ability to resist ultraviolet radiation, outdoor weatherability and good friction resistance. According to the experience of Du Pont Company of using this material in construction, the life time of an airship can last about twenty years if the protection layer of its body uses this material.

Helium Diffusion Prevention Layer: Helium is a rare and expensive gas which can diffuse easily. The helium diffusion prevention layer is usually made of cloth painted with chloroprene and butyl rubber. But the defect of such painted cloth is that after it has been twisted several times, its permeability can become serious. Recently the tendency of using plastic films to make helium diffusion prevention layer is growing. Among them polyamide film, polyester film, polyethylene film of high density and polyacrylic film can all be used and the polyester film is the best. Taking polyester film "maila"* produced by Du Pont Company in the United States for example, to satisfy the same requirement for preventing helium diffusion, the weight of this film constitutes only one fifth of that of the chloroprene gum layer. The helium permeability can decrease from 1.0 litre/m²/day when the painted cloth is used to 0.5 litre/m²/day if this film is used. This material has adequate shearing strength and never, like the varnished cloth, needs biased fabric to bear the shearing stress. Obviously, it is a tremendous help to promote the strength/weight ratio of body material of a non-rigid

* Translator's note: "maila" is a transliteration of Chinese pronunciation.

airship to use polyester film of high density. Polyethylene film of high density is now used in large quantity to build plastic airship to make high altitude survey. In 1973, Japan successfully built a plastic airship of two hundred thousand square meters by using this material and the airship can carry survey equipment of hundred kilograms to fly at an altitude of 43 kilometers. Someone thinks that the polyethylene film would be a suitable material to build the body and air bag of an airship.

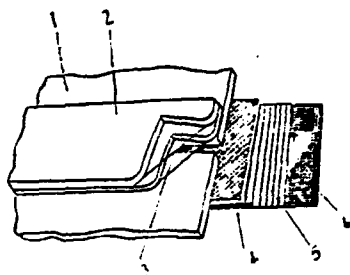


Figure 3 The structure adjacent to the seaming
1. outer layer; 2. polyvinyl-fluoride double-covering plate; 3. transparent gum layer; 4. black gum layer; 5. 1000 denier fibre layer; 6. polyester fabric double-covering plate

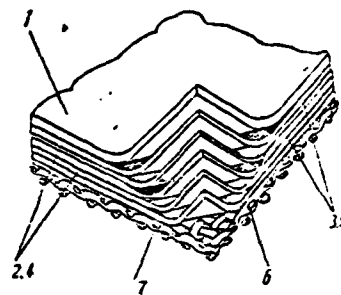


Figure 4 The structure of ply-material
1. polyvinyl-fluoride protection layer; 2. & 4. black gum layer; 3. & 5. helium diffusion prevention polyester film "maila"; 6. transparent gum; 7. polyester fibre stress bearing layer

Stress Bearing Layer: Generally the stress bearing layer is made of nylon and polyester fabrics. The latter has excellent dimensional stability, high strength, high tear resistance and hydrolytic stability and it is almost completely used to replace the former as body material of non-rigid airship nowadays. Recently in the United States, Du Pont Company produces a polyamide fibre which belongs to aromatic family and has high modulus and high strength and it is used to replace polyester fibre under a merchandise name

"kaifula" * . It can further promote strength/weight ratio and reduce the permeability, so it is a more advanced fabric material to build the body of an airship.

In some foreign countries, the body materials of non-rigid airship inflated with helium are of two different kinds of structure: one is the varnished fabric structure and the other is the ply material structure. Those which belong to the first kind include the non-rigid airships built by US Goodyear Company, such as "Mayflower", "America", "Columbia" and "Europe", and the helium inflated captive balloon (one kind of non-rigid airship) "CBV-200 A" built by the Schjedaahl Company in the United States. Of those which use double-layer varnished fabric structure, the protection layer is made of chloroprene gum or polyaminoester of polyethylene chlorosulfonated; the helium diffusion prevention layer is made of chloroprene gum or butyl-gum; the stress bearing layer uses one layer of polyester fabric of biased structure to resist shearing force and another layer of polyester fabric as basic stress bearing layer. The structure is showed in Figure 3. The typical structure which belongs to the second kind is shown in Figure 4 . It is a ply-material structure. The protection layer uses polyvinyl fluoroide. The helium diffusion prevention layer is made of polyester film and the fabric is made of polyester fibre. Layers are glued and plyed together. The merits of this kind of structure are that the strength/weight ratio can be promoted and the permeability is low, but the resistance to bending is not good. The helium inflated captive ballon "CBV-250 A" built by the Schjedaahl Company uses this new type of structure. As a result of using new material

* Translator's note: "kaifula" is a transliteration of Chinese characters.

and ply-material structure, the weight of the body material is reduced by forty per cent and the strength is promoted by 5.4 kg/cm. Thus the helium inflated captive ballon "CBV-250 A", because of the improvement of its material, increases its extra static lift force about 500 kilograms. Moreover, it has been proved that it can be used for a period of 18 months without any repairment. The result of laboratory test suggests that it can be used for twenty years. Therefore, there has been a tendency that the body material of a helium inflated airship is widely changed to use ply-material structure. Nevertheless, the varnished fabric structure is still in use today and improvement has been made continuously. The US Goodyear Company, for instance, is trying to build a mixed cargo loading airship and the body will be made by using polyester fabric coated with chloroprene gum, and nylon fabric coated with chloroprene gum is used to make the walls of air chamber.

In building technology, in the earlier days, the shearing, sewing of rubber-coated cloth which has been well sulphurated, and making it into a form through joining and seaming are all made by hands. In recent years, however, as a result of the great development of seaming and forming techniques, the seaming is in the form of abutment joint and the structure of the seaming part is shown in Figure 3. This kind of seaming can have the same performance as required of the body material in strength, permeability and weatherability. The outer layer is covered with polyvinyl-fluoride plates and the inner layer is covered with polyester fabric made of 1000 denier fine fibre (see the glossary). The back of both layers is coated with heat-solidifying glue, and using heating seaming machine with a speed of 1 to 2 meters per minute to seam continuously. Because of the limitation of the

position and geometric form, a few seaming spots requires hot sealing by using bar-shaped soldering gun.

The material of the air bag and the cover of a rigid airship is similar to the body material of a non-rigid airship except that, because the air bag is installed inside the ship, the requirement for weatherability and the ability to resist ultraviolet radiation is not very high, so the protection layer is not necessarily made of such material as polyvinyl fluorid. The requirement of air tightness of the cover material of a rigid airship is not so high as that of the air bag, the helium diffusion prevention layer can be appropriately reduced. On the basis of the position of application and the different requirements of materials, the structure of ply-material or the varnished fabrics can be accordingly modified. It thus can both satisfy the requirements, reduce the weight of the material and save manufacturing cost.

In 1929, the US navy built a small type testing pressure airship "ZMC-2" of metal cover. It uses aluminium alloy of which the thickness is 0.24mm to replace the varnished cloth which was widely used at that time. Now some one has begun to study the possibility of building airship completely of metal material structure.



A Power Propelled
Umbrella-winged Glider

(A Short Story)

By
Xu Xizhan

The squad leader was so much enraptured that he had suffered breathing obstruction. Turning back and forth on his bed, he could not fall asleep. Yesterday he led his squad to attack the bandits who had come across the border to make disturbance. Along the narrow path by the hill side, when they passed over the wide and deep valley and rushed to the place, the bandits had all gone far out of sight. Such a long border line with endless range of mountains, gorges, overhanging precipices and steep cliffs and dense jungle, even if they were on horseback or rode motorcycles, the detour always led them to failure in pursuing and catching their enemy.

In dimness, he remembered that a few days ago, he read an article in a journal describing an umbrella-winged flying vehicle. He then asked himself wouldn't everyone in his squad become winged like an eagle if they could ride on such flying vehicle? All a sudden, he felt as if he had had wings, like an eagle, and could fly over the valleys and the mountains ... (see Figure 1).

Next day, at daybreak, he got up and went to see his instructor and told him about his dream last night that every member in his squad became eagle-

man flying above the top of the mountain and pursuing enemy at the foot of the mountain. The instructor said that the dream was very good and that they should try to make it become true. He went back to his squad and told them the story. Soon a discussion meeting took place and it sparked heat arguments. Each attendant earnestly wanted to change their present state of affairs.

The party secretary led to discuss the squad leader's thinking and tried to mobilize the masses soliciting opinions and asking for advices from the wise and abled ones so that he could become able to lead to solve this problem.

Little Chen, a soldier in the squad, had some experience in gliding and gliders because he had learned glider sports from a spare-time gliding school before he joined the army, so he volunteered to take charge of this gliding business. He spent two nights to make a glider model of cardboard. He then went up to the top of a slope, using his glider model to make a gliding demonstration for his comrades. The party secretary approved to set up a "three-in-one" special group and appointed the instructor as its head and the members included the squad leader, Little Chen and technician Sun and Lee from the automobile repair shop to study the making of "eagle-man" glider.



Figure 1 All a sudden, he felt he had had wings ... flying above the top of the mountain and pursuing enemy at the foot of the mountain.

The secretary also ordered that the five machines, chisels, grinders and planes in the repair shop must be used fully in this work.

After two more weeks, Chen and technician Sun successfully obtained several pieces of nylon fabrics used for parachute and a few strong aluminium pipes through herculean efforts. Then the two technicians Sun and Lee and Little Chen began to work. They use two aluminium pipes, one long and one shorter, of which the diameter is 30mm, to make a cross. Then they use two other aluminium pipes of which the diameter is 25mm to solder to the end of the long pipe obliquely and put on the varnished parachute cloth. The horizontal pipe of the cross used as a supporter to the umbrella wing. Underneath the horizontal pipe, there is a vertically standing pipe, of which the diameter is also 30mm, attached to it as a supporter. The foot of this standing pipe is connected with another pipe, of which the diameter is 40mm, stretching forward. At the tail end of the heavy pipe, there is a steering rudder which was taken off from an old glider, and underneath it there is a tail-skid. At the middle, there is another horizontal pipe, of which both ends are equipped with rubber rollers. At the front part, there is a small rubber wheel and at a short distance behind the front wheel there is a pair of pedals joined to the tail rudder by a nylon rope to operate the steering rudder. The length of the wing is more than five meters and the wingspan (the largest width of the wing) is about seven meters. The whole wing area is less than twenty square meters and the airborne weight is 70-80 kilograms (see Figure 2).

They select the highest section of a highway slope to practise gliding.

When they are practising, a political staff officer from a regiment patted Little Chen's shoulder saying with a smile, "Be serious with this practice, our modernization begins with it!"

The glider begins to glide from the highest point of the slope and goes up to an altitude about ten meters from the ground. After flying over a distance about 200 meters, it begins slowly to descend toward the highway.

The regiment political staff officer praised and encouraged Little Chen and the rest of the squad and he then said, "Only gliding, you cannot get far. Can't you add an engine to the glider?"

The instructor, the squad leader, two technicians and Little Chen sit on a stone by the road side staring at the glider and begin to discuss the possibility.